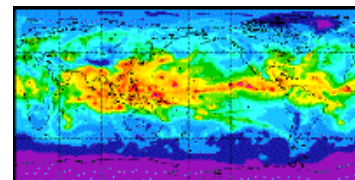


NASA Water Vapor Project (NVAP) Langley DAAC Data Set Document



Summary:

Under a National Aeronautics and Space Administration (NASA) peer-reviewed contract, STC-METSAT has produced a multi-year total and layered (1988-1999) global water vapor data set. The total column (integrated) water vapor data set comprises a combination of radiosonde observations, Television and Infrared Operational Satellite (TIROS) Operational Vertical Sounder (TOVS), and Special Sensor Microwave/Imager (SSM/I) data sets. The global layered water vapor data set is created by slicing the total water vapor data set using layered information that TOVS and radiosonde data provides. As a companion data set for analysis, STC-METSAT also prepared a global (over oceans only), integrated cloud liquid water data set (since the best global climate models now contain liquid water as an explicit variable). The complete data set has been named NVAP, an acronym for NASA Water Vapor Project. STC-METSAT developed methods to process the data at a daily time scale and 1 degree x 1 degree spatial resolution. More information can be found in a journal paper about NVAP ([Randel et.al. 1996](#)). This work has become an internationally accepted contribution to the World Climate Research Programme (WCRP).

NVAP-Next Generation (NVAP-NG) is the latest phase of the NVAP data set, extending it into years 2000 and 2001. With increased power in computers and satellite sensors, the NVAP-NG data products bring increased spatial and temporal resolution. for all specific information relating to the NVAP-NG data sets, please view the [Science and Technology Technical Report 3333](#) (PDF).

This document provides information on the following data sets:

Non-NG Data Sets:

- NVAP_PW_MERGD_MNTHLY
- NVAP_PW_MERGD_PDAILY
- NVAP_SSMI_PW_DAILY
- NVAP_SONDE_PW_DAILY
- NVAP_TOVS_PW_DAILY
- NVAP_SSMI_MNTHLY
- NVAP_SSMI_LWP_DAILY
- NVAP_SSMI_CLW_DAILY

NVAP-NG Data Sets:

- NVAP_NG_CLW_12HOUR
- NVAP_NG_CLW_DAILY
- NVAP_NG_CLW_MONTHLY
- NVAP_NG_CLW_ANNUAL
- NVAP_NG_LWP_12HOUR
- NVAP_NG_LWP_DAILY
- NVAP_NG_LWP_MONTHLY
- NVAP_NG_LWP_ANNUAL
- NVAP_NG_PWC_12HOUR
- NVAP_NG_PWC_DAILY
- NVAP_NG_PWC_MONTHLY
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- NVAP_NG_PWC_STATS

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1. Data Set Overview:

Data Set Identification:

NVAP_PW_MERGD_MNTHLY:	NASA Water Vapor Project (NVAP) Precipitable Water Merged Monthly Grid
NVAP_PW_MERGD_PDAILY:	NASA Water Vapor Project (NVAP) Precipitable Water Merged Pentad Daily
NVAP_SSMI_PW_DAILY:	NASA Water Vapor Project (NVAP) Special Sensor Microwave/Imager (SSM/I) Precipitable Water Daily Grid
NVAP_SONDE_PW_DAILY:	NASA Water Vapor Project (NVAP) Radiosonde Precipitable Water Daily Grid
NVAP_TOVS_PW_DAILY:	NASA Water Vapor Project (NVAP) TIROS Operational Vertical Sounder (TOVS) Precipitable Water Daily Grid
NVAP_SSMI_MNTHLY:	NASA Water Vapor Project (NVAP) Special Sensor Microwave/Imager (SSM/I) Monthly Grid
NVAP_SSMI_LWP_DAILY:	NASA Water Vapor Project (NVAP) Special Sensor Microwave/Imager (SSM/I) Liquid Water Path Daily Grid
NVAP_SSMI_CLW_DAILY:	NASA Water Vapor Project (NVAP) Special Sensor Microwave/Imager (SSM/I) Cloud Liquid Water Daily Grid
NVAP_NG_CLW_12HOUR:	NASA Water Vapor Project (NVAP) Cloud Liquid Water 12 Hour Grid
NVAP_NG_CLW_DAILY:	NASA Water Vapor Project (NVAP) Cloud Liquid Water Daily Grid
NVAP_NG_CLW_MONTHLY:	NASA Water Vapor Project (NVAP) Cloud Liquid Water Monthly Grid
NVAP_NG_CLW_ANNUAL:	NASA Water Vapor Project (NVAP) Cloud Liquid Water Annual Grid
NVAP_NG_LWP_12HOUR:	NASA Water Vapor Project (NVAP) Liquid Water Path 12 Hour Grid
NVAP_NG_LWP_DAILY:	NASA Water Vapor Project (NVAP) Liquid Water Path Daily Grid
NVAP_NG_LWP_MONTHLY:	NASA Water Vapor Project (NVAP) Liquid Water Path Monthly Grid
NVAP_NG_LWP_ANNUAL:	NASA Water Vapor Project (NVAP) Liquid Water Path Annual Grid
NVAP_NG_PWC_12HOUR:	NASA Water Vapor Project (NVAP) Precipitable Water Column 12 Hour Grid
NVAP_NG_PWC_DAILY:	NASA Water Vapor Project (NVAP) Precipitable Water Column Daily Grid
NVAP_NG_PWC_MONTHLY:	NASA Water Vapor Project (NVAP) Precipitable Water Column Monthly Grid
NVAP_NG_PWC_ANNUAL:	NASA Water Vapor Project (NVAP) Precipitable Water Column Annual Grid
NVAP_NG_PWC_STATS:	NASA Water Vapor Project (NVAP) Precipitable Water Column Statistics Grid

Data Set Introduction:

There is a well-documented requirement for a comprehensive and accurate global moisture data set to assist many important scientific studies in atmospheric science. Currently, atmospheric water vapor measurements are made from a variety of sources including radiosondes, aircraft and surface observations, and in recent years, by various satellite instruments. Creating a global data set from a single measuring system produces results which are useful and accurate only in specific situations and/or areas. Therefore, an accurate global moisture data set has been derived from a combination of these measurement systems.

Objective/Purpose:

To assist scientific studies in atmospheric science, primarily those dealing with the atmospheric hydrologic cycle, and to provide a comprehensive and accurate global water vapor dataset to help understand water vapor's role in the Earth's climate system.

Summary of Parameters:



NVAP_PW_MERGD_MNTHLY:	Precipitable Water
NVAP_PW_MERGD_PDAILY:	Precipitable Water
NVAP_SSMI_PW_DAILY:	Precipitable Water
NVAP_SONDE_PW_DAILY:	Precipitable Water
NVAP_TOVS_PW_DAILY:	Precipitable Water
NVAP_SSMI_MNTHLY:	Cloud Liquid Water, Liquid Water Path, Precipitable Water
NVAP_SSMI_LWP_DAILY:	Liquid Water Path
NVAP_SSMI_CLW_DAILY:	Cloud Liquid Water
NVAP_NG_CLW_12HOUR:	Cloud Liquid Water
NVAP_NG_CLW_DAILY:	Cloud Liquid Water
NVAP_NG_CLW_MONTHLY:	Cloud Liquid Water
NVAP_NG_CLW_ANNUAL:	Cloud Liquid Water
NVAP_NG_LWP_12HOUR:	Liquid Water Path
NVAP_NG_LWP_DAILY:	Liquid Water Path
NVAP_NG_LWP_MONTHLY:	Liquid Water Path
NVAP_NG_LWP_ANNUAL:	Liquid Water Path
NVAP_NG_PWC_12HOUR:	Precipitable Water
NVAP_NG_PWC_DAILY:	Precipitable Water
NVAP_NG_PWC_MONTHLY:	Precipitable Water
NVAP_NG_PWC_ANNUAL:	Precipitable Water
NVAP_NG_PWC_STATS:	Precipitable Water

Discussion:

An extensive global dataset of water vapor (WV) has been produced from combining three independent data sources. The dataset includes total column integrated values, and values for three atmospheric layers for 1988 - 1999, and five atmospheric layers for 2000-2001. Each of the individual input datasets has significant limitations: microwave retrievals are presently feasible only over oceans; infrared satellite techniques only work in the absence of significant cloud cover; and radiosonde measurements are made primarily over land and are widely spaced, not showing small-scale WV variations. A comprehensive global dataset should draw upon the strengths of each of these methods and use the advantages of each for all meteorological and geographical scenarios. The NASA Water Vapor Project (NVAP) result is a combined column WV product far better than any single input dataset. In addition, a single method has been derived using the layered WV from radiosondes and TOVS retrievals to slice the total column WV and create the three-layer global WV dataset.

There are three primary NVAP products: total column WV, Liquid Water Path (LWP) derived from the SSM/I and available only over the oceans, and layered WV. In addition, supplemental products such as SSM/I WV, radiosonde WV, TOVS WV, cloud liquid water, and Data Source Code (DSC) for total column and layered WV are provided. These products are available in four possible temporal averaging periods for 1988-1999: day, month, pentad, and annual, and five temporal averaging periods for 2000-2001: 12 hour, daily, monthly, annual.

Related Data Sets:

SSM/I - LWP: Liquid Water Path
SSM/I - CLW: Cloud Liquid Water
SSM/I - PWC: Precipitable Water Content

2. Investigator(s):

Investigator(s) Name and Title:

David L. Randel, Ph. D.
Thomas H. Vonder Haar, Prof.
Graeme L. Stephens, Prof.

NVAP-NG: Thomas H. Vonder Haar, Prof.



Title of Investigation:

NASA Water Vapor Project Data Set (NVAP)
NASA Water Vapor Project - Next Generation Data Set (NVAP-NG)

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3. Theory of Measurements:

NVAP is a weighted blending of precipitable water (or Water Vapor) from satellite retrievals (TOVS and SSM/I) and *in situ* observations from the global radiosonde network. NVAP-NG combines a changing cast of over 10 polar-orbiting instruments to create a global water vapor data set.

4. Equipment:

Sensor/Instrument Description:

Collection Environment:

NVAP:	NVAP-NG:	
<ul style="list-style-type: none">• RADIOSONDE• SSM/I• TOVS	<ul style="list-style-type: none">• AMSU-A/B• ATOVS Soundings• SSM/I• SSM/T-2	<ul style="list-style-type: none">• Sea Surface Temperature and Sea Ice Data• TMI Products• TOVS Pathfinder Reanalysis• Topography

Source/Platform:

NVAP:	NVAP-NG:	
<ul style="list-style-type: none">• DMSP-F8• DMSP-F10• DMSP-F11• DMSP-F13• DMSP-F14• NOAA-10• NOAA-11• NOAA-12• NOAA-14• GROUND STATION	<ul style="list-style-type: none">• AMSUB-N15• AMSUB-N16• ATOVS-N16• MODIS-Terra• SSM T2-F12• SSM T2-F15	<ul style="list-style-type: none">• SSMI-F11• SSMI-F13• SSMI-F14• SSMI-F15• TOPEX_Poseidon• TRMM-TM1

Source/Platform Mission Objectives:

For NVAP-NG related source/platform information, please see the [Science and Technology Technical Report 3333](#) (PDF).

Defense Meteorological Satellite Program (DMSP): The DMSP mission is to provide global visible and infrared cloud data and other specialized meteorological, oceanographic and solar-geophysical data in support of world wide Department of Defense (DoD) operations.

NOAA-10, NOAA-11, NOAA-12, NOAA-14: The mission objective of the NOAA satellites is to provide data for near-real-time weather forecasting.

GROUND STATION: The main objectives are to provide radiosonde data for synoptic charts, forecasting models and to create a useful

climatological data set.

Key Variables:

NVAP_PW_MERGD_MNTHLY:	Precipitable Water
NVAP_PW_MERGD_PDAILY:	Precipitable Water
NVAP_SSMI_PW_DAILY:	Precipitable Water
NVAP_SONDE_PW_DAILY:	Precipitable Water
NVAP_TOVS_PW_DAILY:	Precipitable Water
NVAP_SSMI_MNTHLY:	Cloud Liquid Water, Liquid Water Path, Precipitable Water
NVAP_SSMI_LWP_DAILY:	Liquid Water Path
NVAP_SSMI_CLW_DAILY:	Cloud Liquid Water

Principles of Operation:

RADIOSONDE

Radiosondes carry temperature, pressure and relative humidity sensors and report up to six variables: pressure, geopotential height, temperature, dewpoint depression, wind direction and wind speed. While there are many effective instrument designs in use, in the United States, a typical radiosonde configuration consists of a baroswitch that implements a temperature-compensated aneroid capsule to move a lever arm across a commutator plate, a lead-carbonate coated rod thermistor about 0.7 mm in diameter and 1-2 cm long, and a carbon humidity element that swells with a rise in humidity, made of a glass or plastic substrate thinly coated with a fibrous material. A radio transmitter and ground-based radar, navigation aid, or other tracking system complete the rawinsonde instrumentation. Measurements are used in weather forecasting, and are of increasing interest to those studying climate change.

SSM/I

The SSM/I is flown aboard Defense Meteorological Satellite Program (DMSP) satellites [DMSP-F8](#), DMSP-F10, [DMSP-F11](#), DMSP-F12, DMSP-F13, and DMSP-F14.

The SSM/I is a seven-channel, four-frequency, linearly-polarized, passive microwave radiometric system which measures atmospheric, ocean and terrain microwave brightness temperatures at 19.35, 22.235, 37.0, and 85.5 GHz.

The SSM/I rotates continuously about an axis parallel to the local spacecraft vertical and measures the upwelling scene brightness temperatures. The absolute brightness temperature of the scene incident upon the antenna is received and spatially filtered by the antenna to produce an effective input signal or antenna temperature at the input of the feedhorn antenna. The passive microwave radiometer output voltages are transmitted to both the Air Force Global Weather Central (AFGWC), Offutt Air Force Base, Nebraska and the Fleet Numerical Meteorology and Oceanography Center (FNMOC), Monterey California.

At both locations, the radiometer output voltages are converted to sensor counts. The AFGWC sensor counts are relayed to the National Environmental Satellite, Data, and Information Service (NESDIS), reformatted into the NESDIS Level 1b format and used by NESDIS in generating temperature sounding data sets from another instrument. FNMOC converts their sensor counts into antenna temperatures (TDR), brightness temperatures (SDR), and derived geophysical parameters (EDR). The TDRs, SDRs, and EDRs are sent to NESDIS for archival. The FNMOC antenna temperatures are used as the basis for the SSM/I antenna temperature and geophysical parameter data sets produced by Remote Sensing Systems (Wentz data set) ([Wentz, 1991](#)).

TOVS

The TOVS system consists of three instruments: the High Resolution Infrared Radiation Sounder (HIRS/2I), the Stratospheric Sounding Unit (SSU), and the Microwave Sounding Unit (MSU). All three instruments measure radiant energy from various altitudes of the atmosphere, and the data are used to determine the atmosphere's temperature from the Earth's surface to the upper stratosphere.

HIRS/2I: This instrument detects and measures energy emitted by the atmosphere to construct a vertical temperature profile from the Earth's surface to an altitude of about 40 km. Measurements are made in 20 spectral regions in the infrared band. Note that one frequency lies at the high frequency end of the visible range.

SSU: Temperature measurements from the upper stratosphere are derived from radiance measurements made in three channels using a pressure modulated gas (CO₂) to accomplish selective bandpass filtrations of the sampled radiances. The gas is of a pressure chosen to yield weighting functions peaking in the altitude range of 25 to 50 km where atmospheric pressure is from 15.1 to 1.5 mbar respectively. This gas is contained in three cells, one of which is located in the optical path of each channel.



MSU: This unit detects and measures the energy from the troposphere to construct a vertical temperature profile to an altitude of about 20 km. Measurements are made by radiometric detection of microwave energy divided into four frequency channels. Each measurement is made by comparing the incoming signal from the troposphere with the ambient temperature reference load. Because its data are not seriously affected by clouds, the unit is used along with the HIRS/2I to remove measurement ambiguity when clouds are present.

5. Data Acquisition Methods:

Data was provided to the DAAC via 8mm exabyte tapes from STC-METSAT.

6. Observations:

Data Notes:

Radiosonde data is normally gathered twice daily. Both SSM/I and TOVS are on polar orbiting satellites, thereby providing two local daily passes over every point on the globe.

7. Data Description:

Spatial Characteristics:

Spatial Coverage:

All NVAP products are on a global grid.

Spatial Coverage Map:

All global areas.

Spatial Resolution:

NVAP: 1 x 1 degree global grid.

NVAP-NG: 0.5 x 0.5 degree global grid.

Projection:

Cylindrical Equidistant.

Grid Description:

Data is centered on 180 degrees with the first data point at the North Pole.

Temporal Characteristics:

Temporal Coverage:

NVAP: January 1988 - December 1999.

NVAP-NG: January 2000 - December 2001.

Temporal Coverage Map:

All days during the period.

Temporal Resolution:

NVAP: Daily, pentad, monthly, and annual averages.

NVAP-NG: 12 hour, daily, monthly, and annual averages.

Data Characteristics:

For NVAP-NG related data characteristics, please see the [Science and Technology Technical Report 3333](#) (PDF).

Parameter/Variable:

RADIOSONDE DATA:

An excellent data set to begin creation of a water vapor product is radiosonde data. It is a data set with a long history and is considered "truth"



in the science community. Radiosonde data sets were examined from various sources which required significant processing time and quality control. After NVAP was started, a radiosonde data set was made available by [Mr. W.P. Elliot](#) (Air Resources Laboratory [ARL]/National Oceanic and Atmospheric Administration [NOAA]). Due to the high quality of this set, it was obtained and used for the entire 12 years of NVAP product.

STC-METSAT received the radiosonde ASCII text files from ARL/NOAA via ftp. These files included all the station information at 5 layers. The processing of the radiosonde data involved taking the 5 layers of precipitable water content (PWC) and producing three layers (surface-700 mb, 700-500 mb, 500-300 mb) and the total column PWC. These data were then put into 1 degree x 1 degree size boxes in a gridded format.

The following is a brief overview of Mr. Elliot's data processing and quality control:

The original source of these data was the Global Telecommunications System. This system provides radiosonde data for synoptic charts and forecasting models. NCAR decoded and supplied the data to Mr. Elliot's group. From some 1800 stations that have reported since 1973, approximately 900 have been processed. Since the main objective of this processing was to create a useful climatological data set, the stations chosen required a long history of records.

For each station 00Z and 12Z soundings were used. Temperature, dewpoint depression, surface pressure, and geopotential heights were extracted for the mandatory levels (surface, 850, 700, 500, 400, and 300 mb). The soundings were terminated at the 300 mb level since humidity measurements are not reliable past this point. Significant levels (including 1000 and 925 mb) were also saved with temperature and dewpoint depression. From this information, dewpoint, relative humidity, and specific humidity were calculated at each level, with precipitable water, temperature, and dewpoint lapse rate between each layer.

The main advantage of using this data set is the extensive quality control performed on it. These were an outgrowth of the many errors discovered in individual soundings when using radiosonde data in climate studies ([Elliot and Gaffen, 1991](#)).

Each sounding is checked for the number of levels with valid data. Any observations from stations above 700 mb were not included. An individual sounding is kept if the pressure, temperature, and dewpoint at the surface, 850 mb, and 700 mb levels are present and within acceptable limits. Each parameter has a unique set of limits as described below.

Surface pressure:

- a. Maximum surface pressure is 1060 mb at sea level. Above sea level, the maximum is adjusted using density as a function of station elevation and the hydrostatic equation.
- b. Minimum surface pressure equals surface maximum minus 110 mb

Dewpoint depression:

- a. This must be equal to or greater than zero and be equal to or less than 49 (UNITS).

Temperature:

- a. For mandatory levels, a climatological monthly station mean is computed with 1973-1991 data. Any temperature outside plus or minus 4 standard deviations from this mean fails the check.
- b. For significant levels, temperature was checked against the limits for the surrounding mandatory levels.
- c. If a temperature failed a check at a mandatory level 700 mb or below, the entire sounding was discarded. Above 700 mb, the sounding was kept, but data above the last valid level was discarded. This allows level data containing the bulk of water to be retained.

Failure at a significant level resulted in that particular level being ignored, but the sounding was retained.

Only two adjustments were made to soundings under certain circumstances, both of which were to humidity measurements made under U.S. procedures. When a temperature is below -40 C, the customary U.S. procedure is to discontinue humidity readings ([Elliot and Gaffen, 1991](#)). However, Canada reports humidity down to -65C. Taking the median measure from the Canadian data, relative humidity is adjusted to 50 at mandatory levels 500, 400, and 300 mb if temperature is less than -40 and dewpoint is missing.

Another U.S. procedure reports relative humidity less than 20 as 19 and dewpoint depression as 30. If 30 was used as the dewpoint depression, the relative humidity would generally be too low. This can lead to a "dry bias". However, using 19 (or treating the data as missing) can lead to a "moist bias". Instead, a mean Canadian value of 16 was used in this situation.



Radiosonde is a tested and much used data set but has some notable problems some of which include geographically sparse stations and soundings which are generally limited to land. There is also an inconsistency in sensors used throughout the world. These topics are discussed in the [Quality Assessment](#) section.

SSM/I DATA:

Another source used to create the merged PWC is the SSM/I instrument aboard the F8, F10, F11, F13, and F14 Defense Meteorological Satellite Project (DMSP) satellites. The DMSP F8 satellite (launched June 19, 1987) provided data through 1991. The DMSP F11 satellite (launched November 28, 1991) provided data through 1996. The DMSP F10 satellite was launched December 1, 1990 but had problems with its orbit which now precesses in a non-synchronous orbit. We were able to calibrate the F10 data for use beginning January, 1993. The DMSP F13 satellite (launched March 24, 1995) began providing data in May 1995. DMSP-F14 was launched on April 4, 1997. The Wentz routines ([Wentz, 1991](#)) were used to read and process the raw SSM/I antenna temperatures and produce brightness temperatures at various channels along with the angle of incidence and F8 geolocation error corrections. Also provided was a file containing a list of time periods containing erroneous F8 data. This file helped the quality control of the SSM/I data through the years 1988-1990 but seemed to be incomplete for 1991 and 1992 which contained bad orbital swaths.

STC-METSAT used a retrieval scheme based on the physical method employed by [Greenwald et al. \(1993\)](#) extended and improved this physical method to include the retrieval of cloud liquid water. In order to determine the total column water vapor by using the retrieval model of [Greenwald et al. \(1993\)](#), several input parameters are required.

The first parameter is sea surface temperature (SST) ([Reynolds, 1988](#)). NVAP used SST's produced by the National Meteorological Center (NMC) on a 2 degree x 2 degree global grid. We set up a bilinear interpolation routine to use the SST data as a 1 degree x 1 degree grid. Starting with 1993, the SST data came to us at higher resolution, both temporally and spatially. The new 1 x 1 degree spatial resolution meant we did not have to use the bilinear interpolation on the data. And the SST data are now weekly values versus the monthly data we had before.

Other important parameters are the vertical and horizontal components of the SSM/I 19.35 GHz, 22 GHz and 37 GHz brightness temperatures. These were used in an approximate radiative transfer model. In addition, the near surface wind speed is needed in an empirical sea surface emissivity model ([Petty, 1990](#)). To calculate the surface wind speed, the vertical component of the 22 GHz brightness temperature is used in the [Goodberlet et al. \(1989\)](#) surface wind speed algorithm. For SST greater than 300 K, ([Bates 1991](#)) surface wind speed algorithm is used due to problems which the Goodberlet algorithm has in regions with large water vapor amounts. Starting with the 1993 data, we updated the retrieval algorithm to include iterations using the 22 GHz temperatures along with the 37 and 19.35 GHz channels to find the PWC values, instead of using the 22 GHz channel to only calculate the surface winds. We've also added the ISCCP cloud top temperatures for mid-level clouds instead of approximated cloud top values. We improved the wind calculations, iterative schemes and added the ability to input more than one satellite's data since we now have up to three satellites providing data. Overall, the new PWC (1993-1995) values produce a global average PWC about 0.5 mm less than before. This is due to the better performance in the polar regions, leaving more good data in those low value areas. And it seems to be providing more detailed lower PWC values in the mid-latitudes.

For the retrieval routine to produce consistent, stable data throughout all 12 years of processing, the F8 and F11 satellite data were specially calibrated during the month they overlapped (December 1991). Coincident passes were compared and retrieval parameters adjusted accordingly. The F10 was calibrated with F11 to use it beginning 1993. And the F13 was calibrated to the F10 and F11 when we began receiving data for it in May 1995. The F13 and F14 were intercalibrated

The retrieval routine returns pixel values for PWC, liquid water, and wind speeds from the satellites' scanlines. The pixels are combined and averaged into 1 x 1 degree boxes, which produce the SSM/I output grid maps.

Mainly, there are two problems with SSM/I data. One of which is with the brightness temperatures being contaminated by land and the other is contamination due to sea ice. SSM/I is currently used only over oceans. In order to do this a land mask is used to avoid calculating retrievals over land. However, some regions of small islands and rock outcroppings are not included in the mask. These cause occasionally high values in specific island areas. The final quality control included searching for these problem areas.

The second problem occurs when the sensor encounters sea ice. It will produce values higher than the actual temperature. This can occur around polar coastal regions but does migrate north and south in accordance with the seasons. Employing a sea ice detection routine allowed for the removal of these bad points. Sea ice areas were also explicitly looked for in quality control. We changed the sea ice detection routine starting with the 1993 data. Before, we detected sea ice at the pixel level using a simple version of the AES/YORK algorithm developed for the SSM/I calibration/validation effort ([Hollinger et al. 1991](#)). We changed the sea ice detection routine to use a method by [Cavalieri et al. \(1991\)](#). It means ice concentration in a specified area is +15, roughly corresponding to sea ice edge. We also included a method by [Grody \(1991\)](#) to locate permanent ice. These methods improved our sea ice detection, especially around coastlines.

We also added an oceanic precipitation contamination test. We use the [Grody \(1991\)](#) algorithm already in place within the sea ice detection routine. The algorithm, an 85.5 GHz scattering index, returns a surface type classification including oceanic precipitation.

SSM/I Intersatellite Calibration

New knowledge about the SSM/I instrument calibration became available during the production of the new NVAP-Next Generations products (NVAP after 1999). The findings of Colton and Poe (1999) have been applied to the SSM/I data to produce a TCWV product which has reduced effects of satellite changes. In essence, by working back in time the SSM/I retrievals were normalized to each other so they could be brought forth in time in a seamless manner.



From examining the effects of the intercalibration on a small subset of data over 1995-1999, the estimated effects of the intercalibration procedure are as follow:

ESTIMATED NVAP CORRECTIONS		
1/95 - 4/97	add 0.39 mm	F11 and F13 Satellites
5/97 - 4/99	add 0.26 mm	F11, F13, and F14 Satellites
5/99 - 12/99	add 0.51 mm	F13 and F14 Satellites

These corrections cannot be applied to the current NVAP PWC. The corrections were made at the brightness temperature level and are not an offset, and neither are they linear with TCWV amount. The values can be added to the global daily average ocean grid point values. The correction seems like a small amount but is relevant to climate variability studies since it could obscure anomalies from Earth's natural variability such as El Nino episodes.

The entire 1988-1999 NVAP dataset was processed with a consistent SSM/I antenna pattern. New results on the antenna pattern correction and its impact on the TB's were presented in Colton and Poe (1999). This correction has not been applied to any of the 1988-1999 NVAP data at the NASA Langley Atmospheric Science Data Center. Its main effect is on the time-series of the value of the water vapor anomaly. Figure 1 shows the estimated impact of this correction after 1995 on the global anomaly. This correction can be considered a fine adjustment to normalize the several different SSM/I instruments used in NVAP. Future proposed work may involve reanalysis of NVAP to look at the effect of the SSM/I antenna pattern correction.

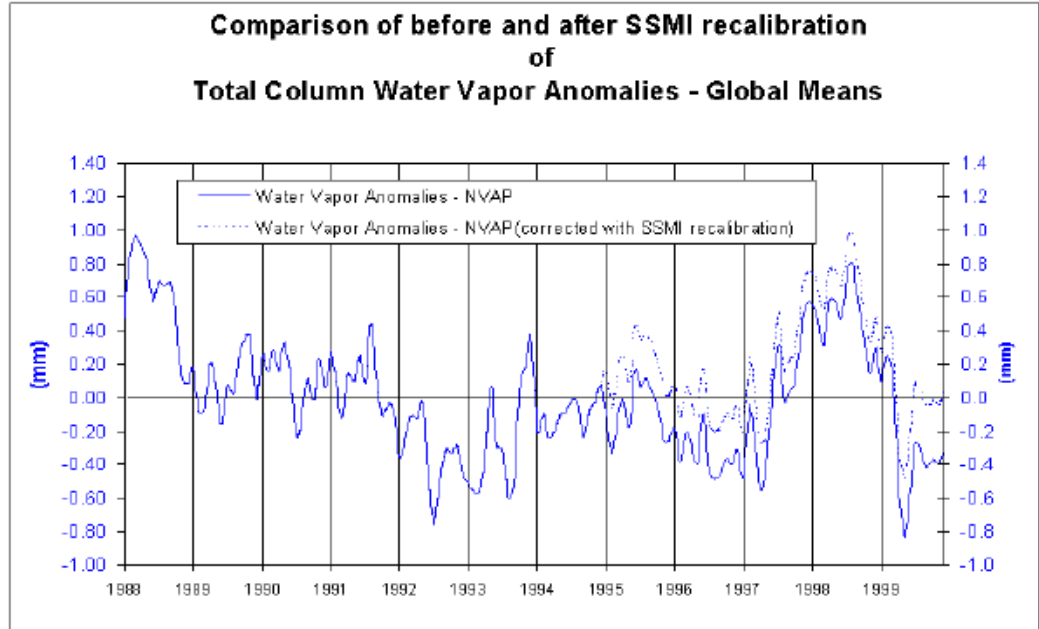


Figure 1: Comparison of before and after SSMI recalibration of total column water vapor anomalies - global means.

TOVS DATA:

Operational satellite-based PWC retrievals have been made since 1978 by NOAA/National Environmental Satellite Data and Information Service (NESDIS) ([Werboutzki 1981](#)), using raw data collected from the NOAA series of operational polar-orbiting satellites. The NOAA satellites have a near-polar sun-synchronous orbit with a 102-minute period. Carried aboard these platforms is the TOVS instrument package for retrieval of atmospheric temperature, ozone, and water content. The TOVS system is made up of the second-generation High Resolution Infrared Radiation Sounder (HIRS/2), the Microwave Sounding Unit (MSU), and the Stratospheric Sounding Unit (SSU). All three instruments are used for retrieval of vertical temperature and moisture profiles. Both the HIRS/2 and the MSU instruments are cross-track scanners, capable of sensing a swath 2250 km wide. The HIRS/2 spectrometer has 19 infrared channels and one visible channel, and are operated simultaneously during each scan (see [Wu et al. 1993](#) for a discussion of related brightness temperature standard errors). Radiance data from HIRS/2 and MSU channels used primarily for temperature sounding are utilized by the operational NESDIS retrieval scheme for determining water vapor content in three layers. A statistical eigenvector regression method was used before 16 September 1988, and was succeeded thereafter by a physical scheme ([Reale et al. 1989](#)) where temperatures and moisture profiles are generated in a single-solution vector. Three channels in water vapor absorption bands are located at 6.7, 7.3, and 8.3 micrometers with weighting functions peaking at 400, 600, and 900 mb, respectively.

STC-METSAT used the operational TOVS sounding produced by NESDIS. This quality controlled radiance data is available on 8-mm tapes from other members of the water vapor science community (e.g. John Bates at NOAA/Cooperative Institute for Research in Environmental Science [CIRES]). These data were not gridded but included total and 3-layered PWC for approximately 25,000 retrievals per day with geographical spacing of approximately 2 degrees. Processing consisted of gridding this data into 1 degree x 1 degree boxes. The quality control needed was minimal and was done during the merge process when all three data sets were compared. The few points found to be bad



were usually in desert or coastline areas. Beginning with 1994, the TOVS data set we were receiving doubled in size. The computer hardware and software available to the collection site was upgraded, allowing them to retrieve much more of the data from the satellite. The coverage is now much more complete, improving the NVAP product, especially over land.

There are two problems inherent in all infrared moisture retrievals that tend to limit the dynamic range of the TOVS data. First, the inability to perform retrievals in areas of thick clouds can cause a "dry bias" ([Wu et al. 1993](#)). Second, limitations in infrared radiative transfer theory can cause significant overestimation of water vapor in regions of large-scale subsidence ([Stephens et al. 1994](#)). For these reasons, SSM/I data are given a higher total column water vapor confidence level than TOVS data.

Variable Description/Definition:

The three input data sets described in the previous section each have their own limitations. Radiosonde data is typically over land and even then, is still too sparse to examine small scale atmospheric moisture fluctuations. TOVS satellite data cannot be used in cloudy regions. SSM/I data currently is contaminated by land and sea ice. Therefore, STC-METSAT has combined the three sets together to form a merged product.

To create the water vapor product (PWC) the input data sets are individually gridded into three 1 x 1 degree global grid maps. The SSM/I grid map is then checked for missing data over the oceans. SSM/I regions are then segmented in to specified sizes which are spatially interpolated. SSM/I is considered more accurate in measuring water vapor than the TOVS instrument, hence the need for a weighting scheme when the three input sets are merged together. To begin, each radiosonde point is placed on the grid map. Next, the SSM/I grid and TOVS grid are combined together using a weighting of 10 TOVS and 90 SSM/I for coincident points. These are recorded in a data source code (DSC) map which describes the origin of each point in the merged product using a number scheme (8 to 0 with 8 being the highest confidence level and 0 being the lowest confidence level). With decreasing confidence after the radiosonde points (confidence level 8) are the TOVS/SSM/I combination points (confidence level 7), SSM/I only points (confidence level 6), SSM/I interpolated points combined with TOVS (confidence level 5), SSM/I interpolated points (confidence level 4) and TOVS only points (confidence level 3).

The total merged PWC product is not finished until it is checked for missing data. Missing regions smaller than a specified size are spatially interpolated. This data is given a confidence level of 2. The remaining areas missing data are filled in using a temporal 3-day running average. This data is given the lowest confidence (confidence level 1) except for any possible missing data (confidence level 0).

An important part of the NVAP data set was the layered PWC. The vertical definition of water vapor is important to the moisture transfer process. These types of data sets have never been readily available before as a global product.

Two of the three input data sets contain layered information. This information is used to create the layered PWC. The TOVS data were received in three layers: surface to 700 mb, 700-500 mb, and 500-300 mb. The data were then gridded into a 1 degree x 1 degree grid box for each of the three layers. The radiosonde data came with more than three layers of information. These layers were added to the radiosonde to create three matching layers for the TOVS data.

At this time some basic assumptions on the global PWC distribution were made in order to progress with the layered processing. Layered information from both TOVS and radiosondes were used to 'slice' the total merged PWC product. The reasoning is while the TOVS total PWC may not be as accurate as SSM/I, the fraction of total column PWC in each layer is relatively accurate. While the total PWC may change rapidly in space and time, the fraction of the total PWC in each layer changes much more slowly. The variability in the percent-of-the-total (POT) is a strong function of latitude and season and does not vary spatially as quickly as the PWC. These two assumptions led to the creation of three global grids (for each day) of the POT PWC (one for each of the three layers using a combination of radiosonde and TOVS retrievals).

These POT grids are then spatially interpolated to cover small missing areas. A temporal 5-day running average is used to fill in larger gaps. A 5-day average can be used (versus a 3-day average in the total merged PWC) because slower time variability of the POT of the PWC.

A DSC map is provided for each of the daily layered POT grids (5 to 0, with 5 being the highest confidence and 0 being the lowest confidence). In order of highest to lowest confidence: radiosonde only is the highest (confidence level 5); coincident TOVS/Radiosonde points are combined together using a weighted 10 TOVS and 90 Radiosonde (confidence level 4); TOVS only points (confidence level 3); spatially interpolated (confidence level 2); and temporally filled data has the confidence level 1. Remaining missing data is given the lowest confidence level (confidence level 0). There are increasing areas of missing data with the upper layers, especially in the polar regions due to lack of moisture.

To create the final layered PWC, the total merged PWC grids produced earlier are multiplied by the POT grids. This gives our layered product the advantage of having SSM/I information in it along with TOVS and radiosonde data.

Results of the layered PWC product shows that in oceanic areas, roughly 75-85% of the total PWC is in the lowest layer. For elevated terrain, roughly 50% of the PWC is in this layer. In some locations, the surface may even be above 700 mb, such as over the Tibetan highlands, in which case the POT for this layer is zero.

Included as a companion data set for analysis (since many GCMs are now beginning to include liquid water as an explicit variable), STC-METSAT also processed the oceanic cloud liquid water path (LWP) on a daily 1 degree x 1 degree grid from the SSM/I processing. The LWP product is the liquid water in any region, cloud or no cloud, and is based upon the physically based method of [Greenwald et al. \(1993\)](#), but at this time covers ocean areas only. Also produced were the daily grids of cloud liquid water content (CLW) which is the liquid water in cloudy-only regions using a threshold of liquid water along with PWC and wind speed requirements.



Unit of Measurement:

Millimeter

Data Source:

SSM/I, TOVS, and RADIOSONDE

Data Range:

0 - 80 mm

Sample Data Record:

ASCII Header (144 bytes) For NVAP Data (included for each grid)

POSITION	# BYTES	TYPE		
1-4	(4)	(A)	Format code (CCDA = Colorado Climate Data Archive)	
5-7	(3)	(I)	HEAD1 (1)	data source code
8-10	(3)	(I)	HEAD1 (2)	parameter number or code
11-11	(1)	(I)	HEAD1 (3)	data type (1=real*4, 2=int*4, 3=int*2, 4=byte) non-VMS (5=real*4, 6=int*4, 7=int*2)
12-16	(5)		blanks	
17-18	(2)	(I)	HEAD1 (4)	start year
19-21	(3)	(I)	HEAD1 (5)	start Julian day
22-23	(2)	(I)	HEAD1 (6)	start hour
24-25	(2)	(I)	HEAD1 (7)	end year
26-28	(3)	(I)	HEAD1 (8)	end Julian day
29-30	(2)	(I)	HEAD1 (9)	end hour
31-34	(4)	(I)	HEAD1 (10)	xsize number horizontal data points
35-38	(4)	(I)	HEAD1 (11)	ysize number vertical data points
39-44	(6)	(F)	HEADR (1)	dx horizontal degree spacing (+ for W to E)
45-50	(6)	(F)	HEADR (2)	dy vertical degree spacing (- for N to S)
51-57	(7)	(F)	HEADR (3)	latitude of first data location (+ for NH)
58-65	(8)	(F)	HEADR (4)	longitude of western most data location
66-76	(11)	(E)	offset for data (add to data after applying scale)	
77-87	(11)	(E)	scale factor for data (multiply data by this)	
88-98	(11)	(E)	ZINDEF	indefinite value
99-104	(6)		blanks	
105-144	(40)	(A)	LABEL	character label

8. Data Organization:**Data Granularity:**

A general description of data granularity as it applies to the IMS appears in the [EOSDIS Glossary](#).

In general:



- Daily fields: 1 month
- Monthly averaged fields: 1 year
- Annual averaged fields: 1 year

Data Format:

The NVAP data set is made up of packed integer*2 (16 bit) records after an ASCII header of 144 bytes (8 bits). Each file can hold many global, 1 degree x 1 degree grids (360 x 180). Coordinate (1,1) is at the North Pole and 0 degrees longitude.

There are three main products: PWC, LWP, and layered PWC. In addition, supplemental products such as SSM/I PWC, radiosonde PWC, TOVS PWC, cloud liquid water (CLW) monthly averages for 1988-1999 and CLW daily averages for 1993-1999, and DSC for PWC and the layered PWC are included. These products are available in four possible file types, depending on the time period covered (i.e., daily, monthly, pentad, and annual).

A daily grid is a grid of a given product for a given day. A full month's worth of daily grids will be contained in one file (e.g., 28 grids for February 1989).

A pentad is a five day average of a given product. A year of these averages is contained in one pentad file.

A monthly grid is an average of the daily grids for a given month. Twelve monthly averages for a given year will be in one file.

An annual grid is the yearly average of the daily grids for a given product.

The NVAP_PW_MERGD_MNTHLY data set contains four types of files: total precipitable water and layered precipitable water, each are the total merged product in monthly and yearly grids.

The NVAP_PW_MERGD_PDAILY data set also contains four types of files: total precipitable water and layered precipitable water, each are the total merged product in daily and pentad files.

The NVAP_SSMI_PW_DAILY data set contains SSM/I ONLY total precipitable water (PWC) daily grids.

The NVAP_SONDE_PW_DAILY data set contains radiosonde ONLY total precipitable water (PWC) daily grids.

The NVAP_TOVS_PW_DAILY data set contains TOVS ONLY total precipitable water (PWC) daily grids.

The NVAP_SSMI_MNTHLY data set contains three types of files for each month from the SSM/I data only: cloud liquid water (CLW), liquid water path (LWP) and precipitable water content (**PWC), each in monthly grids. CLW and LWP contain data spanning the full twelve years of the NVAP project. **PWC is a new parameter that has been added to the data set with data spanning January 1993 to December 1999.

The NVAP_SSMI_LWP_DAILY data set contains liquid water path(LWP) files on a daily basis. This data set spans January 1988 to December 1999.

The NVAP_SSMI_CLW_DAILY data set contains cloud liquid water (CLW) files on a daily basis. This data set spans January 1993 to December 1999.

Additional information:

1. The layered product divides the PWC into three layers. These layers are:

L1 = surface to 700 mb
 L2 = 700 mb to 500 mb
 L3 = 500 mb to 300 m.

2. DSC files for the total PWC grids are identical in size to the corresponding data grid. It shows how each grid point is derived. Data in this file are integers from 0-8, having the following definitions:

0 = Missing data
 1 = Time interpolated-filled
 2 = Space interpolated-filled
 3 = TOVS only
 4 = SSM/I interpolated
 5 = SSM/I interpolated / TOVS combination
 6 = SSM/I only



7 = TOVS and SSM/I combination

8 = Radiosonde data only

The data is ordered by increasing confidence.

The data source code files for the layered PWC grids are also identical in size to the corresponding data grid. Data in these files are integers from 0-5, having the following definitions:

0 = Missing data

1 = Time interpolated-filled

2 = Space interpolated-filled

3 = TOVS only

4 = TOVS and Radiosonde combination

5 = Radiosonde data only

3. In addition, there are FORTRAN routines provided to read the data within the user's own program. These have been tested on HP-UX, VAX_VMS, SGI, PCs running NT, and IBM systems. These routines include a simple test global average routine which calls the read subroutine. This only averages all valid points with no geographical area weighting. Also included is a simple printout routine which creates an ASCII listing file. The VMS switch was tested on a VAX 4000/90 running open VMS 6.0. The HP switch was tested on a HP 9000/735 running HP-UX 9.05. The SGI switch was tested on a SGI running IRIX 5.2.

4. HEADER.TXT file ([see Sample Data Record section](#)) which describes the ASCII header on the NVAP files. These values are filled into the common block used to pass the header and grid point data.

9. Data Manipulations:

For NVAP-NG related data manipulations, please see the [Science and Technology Technical Report 3333](#) (PDF).

Formulae:

Derivation Techniques and Algorithms:

As described in [Data Organization](#), a weighted blending of the three data-sets with confidence from greatest to least: Radiosonde, SSM/I, then TOVS.

Data Processing Sequence:

Create global 1x1 grids of PWC for each input product, then apply weighted blending scheme.

Processing Steps:

PWC grids created and manually, visually quality controlled. Bad data points from one or more of the 3 input data-sets. Blended PWC created again and checked.

Calculations:

Special Corrections/Adjustments:

No data were ever corrected. When bad points were found they were removed.

Calculated Variables:

Percent of Total PWC in Each Layer

PWC from TOVS, Radiosonde, SSM/I

Layered PWC (Surface-700mb, 700mb - 500mb, 500mb - 300mb)

Total PWC

Graphs and Plots:

Not applicable.

10. Errors:



For more information on errors related to NVAP-NG data sets, please see the [Science and Technology Technical Report 3333](#) (PDF).

Sources of Error:

Errors come from many sources. These include error in the retrieval schemes from TOVS and SSM/I and general instrument errors from radiosondes.

Quality Assessment:

In order to produce a quality product, quality control is essential. An important aspect with this data set was the human interaction. Every daily image has been viewed by various meteorologists which helps to insure a high level of quality in our product.

With each input data set, there are certain conditions for which the water vapor calculation may be inaccurate. Knowledge of these conditions enabled the NVAP Quality Control Team to focus on possible problem areas and to recognize possible false values. Other factors such as climate, terrain, and time consistency were also taken into account.

Two main problems with SSM/I measurements are land and sea ice contamination with sea ice being the most common. Either will cause false high values, making detection fairly easy in most cases. While a seasonal brightness temperature threshold is used to take out the more consistent sea ice contaminated areas, some still remain. Most high latitude seas next to land areas tend to have this problem, including waters adjacent to Antarctica, Greenland, Siberia, and Japan. Often such contamination will appear as a string of high values along shorelines.

Land contamination is minor problem compared to sea ice since land does not move as much and is easier to mask. However, areas containing many small islands or rock outcroppings can occasionally contaminate the signal. One such area is around the South Georgia and South Sandwich Islands, southeast of Argentina. Usually, land contamination will appear as a single, high value.

Another occasional problem for SSM/I are bad orbital swaths. In the first three years of this project (1988-1990), these were well documented and taken out during processing. However, in 1991 and 1992, the documentation appeared to be incomplete. Thus a number of undocumented bad swaths slipped through normal processing. These are usually easy to recognize upon visual inspection, due to their banana shapes and markedly different PWC values from surrounding areas.

Use of the Elliot's radiosonde data set greatly reduced the amount of manual quality control required. Most of the unusual or outrageous values had been eliminated. However, there were still a few trouble spots. These would appear as stations that were consistently higher than surrounding radiosonde and satellite measurements. One example is an island station off the coast of Chile. This station tends to be a single, higher value compared with nearby TOVS, SSM/I, and other radiosonde. It was often removed. Other stations checked for this problem included a few Indian and Asian stations.

One possible reason for such a bias is the inherent limitations of various radiosonde instrumentation. There are about a dozen different suppliers of radiosondes world-wide, with wide differences between humidity sensors. The Finnish Vaisala, with a thin film capacitive humidity sensor and the U.S. VIZ, with a carbon hydristor, are considered to have good response times. These instruments are used in the U.S. and European countries and their associates. However, some models have a much slower response time in humidity measurements, especially at upper levels. This lag can cause a moist bias in the readings. India uses a lithium chloride element in their humidity sensors which is known to have a much slower response time than the U.S. or Finnish devices. Another humidity device called "a goldbeater's skin hydrometer" is also known to have a slower response time and it is used by many Asian stations. The slower response of these instruments provides a reasonable explanation for most of the higher values and were removed in these areas.

The TOVS data used as input was previously quality controlled. Thus, manual quality control on the individual data set was minimal. However, a few TOVS points needed to be removed after comparisons with surrounding radiosonde and SSM/I data. Of the few points removed, the majority tended to be in dry or desert regions. These areas included central Australia, Namibia, Western Sahara, the coast of Peru, Kazkh (old USSR), and the Middle East. Such areas are documented to have a "moist bias". Overall, TOVS has a "dry bias" due to the lack of using TOVS in cloudy regions ([Wu et al., 1993](#)). This is caused by the infrared sensor not measuring the entire column's moisture in cloudy regions.

The procedure for manual quality control involved several steps. For all SSM/I data sets, each individual daily grid was visually inspected. Known problem areas as mentioned above were specifically checked. Any other value that did not seem to belong, either visually, climatologically, or in a time series (day before/day after), was checked in the data grid. If a value was suspiciously higher than the surrounding values (for example, a value of 12 mm in a field of 2 mm points), it was removed from the set. Any values that were questionable were marked for later comparison within the total merge product.

After the three input sets were merged together, each daily merged product was visually inspected under the same guidelines as before. Suspect values were noted, then traced to one of the three original data set. Comparisons between the suspicious value and the surrounding values in all three input sets were made. If that value was well above any of the surrounding values in all three sets, the value was removed from the original data set. If the value was close to any of the surrounding values, or if the feature was in at least two of the data sets, it was left in. Once complete, the modified input files were remerged into the final product.

The individual daily product for each of the three merged layers were visually inspected. Since most of the bad individual points were removed in the previous steps, the main thrust of this inspection was to look for anything out of the ordinary. Very few problems were found. These few were usually found in interpolated areas that contained missing data over an extended period of time.

Additional tests were added to the gridding code to assist the manual quality control beginning with the 1993 data. One was a statistical test



which checks the standard deviation of the pixel values within a grid box and throws out the extreme pixel values making for a better averaged grid box value. A second test we added is a spatial test for a grid box when it contains less than 10 pixel values. A normal grid box will contain from 50-150 pixel values which are averaged to get the grid box value. When that grid box has very few pixel values, it has a greater chance of not being consistent with the adjacent grid boxes.

Data Validation by Source:

Each global field was automatically and manually quality controlled at least twice during the blending process to remove out-of-range values.

Confidence Level/Accuracy Judgement:

A DSC global grid is supplied with each daily field for both the total and layered PWC products. As described in the [Variable Description/Definition section](#), the DSC is ordered by confidence (or assumed error). Generally the radiosonde observations have the least error or greatest confidence, then SSM/I then TOVS.

Measurement Error for Parameters:

Roughly 200.000000 for TOVS
100.000000 for SSM/I
less than 100.000000 for Radiosonde

Additional Quality Assessments:

This information is not available.

Data Verification by Data Center:

The Langley DAAC performs an inspection process on the data received by the data producer. The DAAC checks to see if the transfer of the data was completed and were delivered in their entirety. Inspection software was developed by the DAAC to see if the code was able to read the granule. The code also checks to see if each parameter of data falls within the proper range. If any discrepancies are found, the data producer is contacted. The discrepancies are corrected before the data are archived at the DAAC.

11. Notes:

Limitations of the Data:

There are periods which have significant missing data from the input satellite data-sets. These are listed in the NVAP data set readme file. This can have a serious impact on the daily blended products, especially on the layered products when TOVS data is missing.

Known Problems with the Data:

Missing data in final products, Temporal inconsistencies when 1 or more of the satellite input data-sets are missing.

Usage Guidance:

Check table of missing input data in the NVAP readme file if using daily fields.

Any Other Relevant Information about the Study:

Some temporal interpolation was used to fill in missing areas. If daily time variability studies are to be done with data-set, these areas must be removed. The data source code grids can be used for this task.

12. Application of the Data Set:

To provide comprehensive and accurate global moisture data to assist many important atmospheric science studies.

13. Future Modifications and Plans:

NVAP goes through 1999, while NVAP-NG extends through 2001. Future possibilities involve extending NVAP into the era of hyperspectral instruments.

14. Software:

Software Description:



Software is supplied which reads data from the files, does the necessary byte swapping as specified by the user, applies scale and offsets from the header information, and returns a (360,180) global array of real numbers.

Software Access:

Supplied with the data at time of order.

15. Data Access:

Contact Information:

Langley DAAC User and Data Services Office
NASA Langley Research Center
Mail Stop 157D
Hampton, Virginia 23681-2199
USA
Telephone: (757) 864-8656
FAX: (757) 864-8807
E-mail: support-asdc@earthdata.nasa.gov

Data Center Identification:

Langley Research Center Distributed Active Archive Center

Procedures for Obtaining Data:

The Langley DAAC provides multiple interfaces to access its data holdings. The graphical and character user interfaces allow users to search and order data; and web interfaces allow direct access to some data holdings for immediate downloading or placing media orders, for searching the data holdings, and downloading electronically available holdings, and for ordering prepackaged CD-ROMs and videocassettes. All of these methods are easily obtained from the [Langley DAAC web site](#).

Data Center Status/Plans:

The Langley DAAC will continue to archive and distribute these data until further notice.

16. Output Products and Availability:

Data sets are available via ftp.

17. References:

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18. Glossary of Terms:

[EOSDIS Glossary.](#)

19. List of Acronyms:

[EOSDIS Acronyms.](#)

AFGWC - Air Force Global Weather Center
ARL - Air Resources Laboratory
CIRES - Cooperative Institute for Research in Environmental Science
CLW - Cloud Liquid Water
DAAC - Distributed Active Archive Center
DMSP - Defense Meteorological Satellite Program
DoD - Department of Defense
DSC - Data Source Code
EDR - Environmental Data Record
EOSDIS - Earth Observing System Data Information System
FNMOC - Fleet Numerical Meteorology and Oceanography Center
ftp - file transfer protocol
GCM - General Circulation Model
GUI - Graphical User Interface
HIRS - High Resolution Infrared Radiation Sounder
IMS - Information Management System
LPW - Liquid Water Path
MSU - Microwave Sounding Unit
NASA - National Aeronautics and Space Administration
NCAR - National Center for Atmospheric Research
NESDIS - National Environmental Satellite, Data, and Information Service
NMC - National Meteorological Center
NOAA - National Oceanic and Atmospheric Administration
NVAP - NASA Water Vapor Project
POT - percent-of-the-total
PW - Precipitable Water
PWC - Precipitable Water Content
SDR - Sensor Data Record



SST - Sea Surface Temperature
SSU - Stratospheric Sounding Unit
STC-METSAT - Science and Technology Corporation - Meteorological Satellite
TDR - Temperature Data Record
TIROS - Television and Infrared Operational Satellite
TOVS - TIROS Operational Vertical Sounder
SSM/I - Special Sensor Microwave/Imager
URL - Uniform Resource Locator
WCRP - World Climate Research Programme
WV - Water Vapor

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